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Evaluating the Impact of Educational Programs on Nurses' Knowledge and Practices in the Care of Patients Undergoing Bone Marrow Transplantation

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Abstract **Background:** Bone Marrow Transplantation (BMT) is a curative treatment for numerous malignant and nonmalignant hematologic disorders. Nurses are pivotal in patient care, requiring up-to-date knowledge and practical competency in BMT-related management. **Objective:** To assess the effect of an educational program on the knowledge and practice of nurses caring for patients undergoing BMT. **Methodology:** A quasi-experimental design involving a convenience sample of 34 nurses from the BMT Unit at Hiwa Cancer Hospital, from March 2023 to September 2024 was adopted. Data were collected using a structured questionnaire comprising demographic details, knowledge assessment and a practice evaluation. Participants attended an 8-session educational program designed to enhance their competencies. **Results:** Baseline assessments revealed that most participants had poor knowledge (67.6%) and practice (73.5%), with mean scores of 0.42±0.23 and 0.63±0.42, respectively. Post-program evaluations showed a substantial improvement in knowledge, with 73.5% of nurses classified as having good knowledge (mean score of 0.79±0.12) ($p<0.001$). Similarly, nurses demonstrating good practices increased from 5.9% to 41.2%, significantly increasing the mean practice score to 1.40±0.29 ($p<0.001$). **Conclusions:** The educational program effectively enhanced the knowledge and practice of nurses managing patients undergoing BMT at Hiwa Cancer Hospital.

Key Words Bone-marrow transplantation; educational program; knowledge; practice; nurses

INTRODUCTION

Bone Marrow Transplantation (BMT) is a Hematopoietic Stem Cell Transplantation (HSCT) and is considered a life-saving therapeutic procedure designed to replace dysfunctional or diseased BM with healthy HSCs. These SCs can be derived from BM, peripheral blood or cord blood and are infused intravenously into the patient following a preparatory conditioning regimen [1]. The primary goals of BMT include augmenting BM function, eradicating malignant tumour cells and replacing dysfunctional cells in conditions like immune deficiency syndromes and hemoglobinopathies [2].

This advanced procedure is widely used to treat haematological malignancies, nonmalignant hematologic disorders, solid tumours and specific inborn errors of metabolism. Indications for BMT include conditions such as acute lymphoblastic leukemia, myelodysplastic syndromes, severe aplastic anemia and autoimmune disorders [3]. The preparatory conditioning regimens, involving chemotherapy, radiation or immunotherapy, aim to eradicate disease, create space for donor cell engraftment and suppress immune rejection. However, the procedure carries risks of complications such as graft failure, Graft-Versus-Host Disease (GVHD), infections, organ damage and psychological stress [4].

The BMT process involves several steps and requires the work of a qualified multidisciplinary team. Nurses are integral members of the multidisciplinary BMT care team, providing comprehensive patient care across all phases of the transplant process from pre-transplant preparation to post-transplant management. Their responsibilities include administering conditioning regimens, managing donor and recipient care, recognizing complications and implementing preventive and therapeutic interventions. Nurses also

provide health education to patients and families, addressing concerns, ensuring adherence to post-transplant care protocols and promoting psychological well-being [1].

Given the complexity of BMT and its associated complications, nurses must possess specialized knowledge, advanced clinical skills and critical decision-making abilities. The nature of nursing work in BMT requires specialized knowledge, advanced clinical skills and complex decision-making abilities to provide individualized, patient-centred care to achieve optimal outcomes. Therefore, continuous education and training are imperative for maintaining competency, ensuring optimal patient outcomes and fostering patient satisfaction. Advanced practice nurses in oncology play a pivotal role in symptom management, improving quality of life and supporting shared decision-making in BMT care [5].

With the increased scope of nurses' activity in the BMT internationally, the discussion on advanced nursing practices has evolved, making it imperative to define the necessary competencies for nurses in this speciality field. The construction of skills favours the professional training process and its application manifests itself in knowing how to act, wanting to act and being able to act [6].

Despite the critical role of nurses in BMT care, gaps in their knowledge and practice persist, potentially impacting patient outcomes. Limited training opportunities and the absence of structured educational programs contribute to these deficiencies. Addressing this issue requires targeted interventions to effectively enhance nurses' competencies in managing BMT patients. This study addresses the pressing need for evidence-based educational programs to improve the knowledge and practice of nurses caring for BMT patients. By identifying and bridging knowledge gaps, the study aims to promote better patient outcomes, reduce complications and enhance the overall quality of care provided in BMT settings.

MATERIALS AND METHODS

Study Design and Setting

A quasi-experimental design was carried out in the BMT Unit, Hiwa Cancer Hospital, Sulaimaniyah City, Iraq, on convenient samples of 34 nurses that provide direct care for patients undergoing BMT, from March 2023 to September 2024.

Ethical Approval

The Scientific and Ethical Committees at the College of Nursing, University of REDACTED, accepted the study protocol (No. 215 on Dec 2022- REDACTED). Before participation, the researchers explained the study's aim, nature and expected outcomes to the nurses to obtain their acceptance and cooperation. The gathered data were kept confidential and used for the study purpose only. Moreover, participation was voluntary and participants had the right to withdraw without any obligation. Informed written consent was obtained from the nurses to publish this report. A copy of the written consent is available for review by the principal author of this study.

Data Collection and Scoring System

Data were collected using the structured interview questionnaire sheet [7,8] that was composed of personal characteristics (age, gender, level of education, years of experience as a nurse, years of experience in BMT units and previous course attainment related to BMT) and nurses' knowledge assessment regarding BMT (general knowledge regarding BMT, knowledge regarding indication/ contraindication of BMT, BMT complication, responsibility before BMT, role in preparation for BMT, care during BMT procedure, care post-transplant, caring for a central venous device, discharge plan and patients' education). Then, the nurses' knowledge was evaluated and checked with a model key answer (yes, no, didn't know). Accordingly, a score (1) was given for correct answers and a score (0) was given for incorrect and didn't know answers. A high score indicated a better level of knowledge and the maximum score was 115. The nurses' total knowledge score was categorized as poor (>50%), fair (50>75%) and good (≥75%).

Additionally, an observation checklist was adapted [7-9] to evaluate nurses' practice before and after implementing an educational program regarding BMT procedures. It consisted of caring for patients pre-BMT (preparation for BMT), caring for patients during BMT and caring for patients after BMT (assessment, monitoring, evaluation, infection control, caring for central venous device, pain management, nutrition and hydration, oral care and mucositis management, psychological and emotional support, nursing action regarding discharge plan and nurse-led patient education). Then, wholly, the performed item was scored (2), the partially performed was scored (1) and the not performed was scored (0). The total score of nurses' practices was categorized into poor (>50%), fair (50>75%) and good (≥75%). Three experts in the field revised the study tools to assess the validity, clarity, relevance, comprehensiveness, simplicity, applicability and sequence of items. Reliability for tools was applied to test the internal consistency by administering it to the same subject under similar conditions. Answers from repeated testing were compared using Cronbach's alpha coefficient test for nurses' knowledge ($r = 0.901$) and for nurses' practice ($r = 0.896$).

A pretest was conducted to assess nurses' knowledge and practice regarding managing patients undergoing BMT. This process was performed for each nurse twice at different times and the mean score for each evaluation was calculated and considered as the score of nurses' practices. Based on baseline data obtained from the pretest assessment, the educational program was designed and developed using simple Kurdish language and coloured photographs to facilitate nurses' understanding. The program's general and specific objectives were clearly outlined and designed to enhance the nurses' knowledge and practice regarding BMT.

Statistical Analysis

Data analysis was conducted using Statistical Package for the Social Sciences (IBM SPSS, version 26, Chicago, USA). The results were presented using appropriate descriptive and

inferential methods. Differences were considered significant at p≤0.05, while highly significant was considered when the p≤0.001 and a p>0.05 indicates non-significant.

RESULTS

The age of most participants (70.6%) falls within 30-40 years and 1/4 was <30 years with a mean age of 32.76±4.62 years, indicating a relatively young workforce. Female nurses dominated (70.6%), suggesting a gender imbalance in the workforce. Regarding educational qualifications, most nurses hold a diploma (67.4%), 26.5% have bachelor's degrees and 8.8% possess postgraduate qualifications. Regarding years of experience as a nurse, 64.7% had 5-10 years, 23.5% had 10-15 years and 11.8% had >15 years of experience with a mean of 10.21±4.68 years, suggesting a moderately experienced workforce. As for experience in the BMT Unit, 61.8% had <5 years and 38.2% had >5 years, with a mean of 4.32±2.67 years, indicating limited exposure to this specialized field. In addition, 64.7% had not attended formal training courses related to BMT, while 35.3% had such training (Table 1).

Table 2 presents the participants' knowledge regarding BMT at baseline and after the educational intervention. At baseline, 50% had poor knowledge, 35.3% had fair and 14.7% had good knowledge. Post-program, 64.7% achieved good knowledge, 29.4% showed fair and 5.9% had poor knowledge. The mean score improved from 0.41±0.29 to 0.82±0.13, reflecting a substantial gain in general knowledge about BMT (p<0.001). At baseline, 52.9% had poor knowledge regarding the indications and contraindications for BMT, 26.5% had fair and 20.6% had good. After the program, those with good knowledge increased significantly to 67.6% and 5.9% had poor knowledge. The mean score improved from 0.44±0.28 to 0.79±0.15 (p<0.001), which enhanced understanding of this critical aspect. In addition, 52.9% had poor knowledge of BMT complications, 29.4% had fair and 17.6% had good. Following the intervention, those with good knowledge increased to 64.7% and 2.9% had poor knowledge. The mean score improved from 0.46±0.29 to 0.79±0.14 (p<0.001), suggesting a marked improvement in participants' awareness of the complications associated with BMT.

Table 3 presents the knowledge regarding nurse responsibility before BMT and preparation before the procedure and post-program. At baseline, 55.9% had poor knowledge, 26.5% had fair and 17.6% had good. After the

Table 1: Distribution of participants' characteristics

Variable		Frequency	Percentage
Age Groups (Years)	<30	8	23.5
	30-40	24	70.6
	>40	2	5.9
Gender	Female	24	70.6
	Male	10	29.4
Qualification	Diploma	22	67.4
	Bachelors	9	26.5
	Postgraduate	3	8.8
Experiences as a nurse (Years)	5<10	22	64.7
	10-15	8	23.5
	>15	4	11.8
Experience at BMT Unit (Years)	<5	21	61.8
	≤5	13	38.2
Training course in BMT	Yes	12	35.3
	No	22	64.7
Total		34	100

BMT: Bone marrow transplant

Table 2: Distribution of participants' knowledge on bone marrow transplant

	Baseline		Post-program		
Levels of knowledge	Frequency	%	Frequency	%	p-value
General Knowledge about BMT					
Poor	17	50	2	5.9	>0.001*
Fair	12	35.3	10	29.4	
Good	5	14.7	27	64.7	
Mean±SD (0-1)	0.41±0.29		0.82±0.13		>0.001**
Indication and contraindication of BMT					
Poor	18	52.9	2	5.9	>0.001*
Fair	9	26.5	9	26.5	
Good	7	20.6	23	67.6	
Mean±SD (0-1)	0.44±0.28		0.79±0.15		>0.001**
Complications of BMT					
Poor	18	52.9	1	2.9	>0.001*
Fair	10	29.4	11	32.4	
Good	6	17.6	22	64.7	
Mean±SD (0-1)	0.46±0.29		0.79±0.14		>0.001**

*Chi-square, **Paired t-test, BMT: Bone marrow transplant

Table 3: Distribution of participants' knowledge before bone marrow transplant

Level of knowledge	Baseline		Post-program		p-value
	Frequency	%	Frequency	%	
Knowledge regarding Nurse responsibility pre-BMT					
Poor	19	55.9	2	5.9	>0.001*
Fair	9	26.5	12	35.3	
Good	6	17.6	20	58.8	
Mean±SD (0-1)	0.44±0.28		0.78±0.13		>0.001**
Knowledge regarding Preparation of BMT					
Poor	18	52.9	2	5.9	>0.001*
Fair	9	26.5	11	32.4	
Good	7	20.6	21	61.8	
Mean±SD (Range 0-1)	0.48±0.27		0.78±0.14		>0.001**

*Chi-square, **Paired t-test, BMT: Bone marrow transplant

Table 4: Distribution of participants' knowledge during bone marrow transplant procedure

Level of knowledge	Baseline		Post-program		p-value
	Frequency	%	Frequency	%	
Poor	19	55.9	2	5.9	>0.001*
Fair	8	23.5	10	29.4	
Good	7	20.6	22	64.7	
Mean±SD (Range 0-1)	0.42±0.31		0.82±0.15		>0.001**

*Chi-square, **Paired t-test

Table 5: Distribution of participants' knowledge post bone marrow transplant care

Level of knowledge	Baseline		Post-program		p-value
	Frequency	%	Frequency	%	
Poor	20	58.8	3	8.8	>0.001*
Fair	8	23.5	10	29.4	
Good	6	17.6	21	61.8	
Mean±SD (0-1)	0.43±0.32		0.79±0.13		>0.001**

*Chi-square, **Paired t-test

Table 6: Distribution of Participants' Knowledge on caring for central venous devices

Level of knowledge	Baseline		Post-program		p-value
	Frequency	%	Frequency	%	
Poor	18	52.9	2	5.9	>0.001*
Fair	10	29.4	8	23.5	
Good	6	17.6	24	70.6	
Mean±SD (0-1)	0.39±0.38		0.81±0.14		>0.001**

*Chi-square, **Paired t-test

intervention, the distribution shifted significantly, as 5.9% had poor knowledge, 58.8% had good and 35.3% had fair. The mean score increased from 0.44±0.28 to 0.78±0.13 post-program, indicating improved participants' understanding of their responsibilities before BMT ($p<0.001$). As for knowledge regarding the preparation of BMT, at baseline, 52.9% had poor knowledge, while 26.5% had fair and 20.6% had good knowledge. After the intervention, those with good knowledge rose significantly to 61.8% and 5.9% had poor knowledge. The mean score improved from 0.48±0.27 to 0.78±0.14 ($p<0.001$).

Table 4 demonstrates participants' knowledge about the BMT procedure following an educational program. At baseline, 55.9% exhibited poor knowledge, 23.5% had fair and 20.6% had good. The mean knowledge score was 0.42±0.31, indicating a limited understanding of the procedural aspects of BMT. After the educational intervention, those with poor knowledge decreased to 5.9%, those with fair knowledge increased to 29.4% and those with good knowledge rose significantly to 64.7%. The mean knowledge score improved markedly to 0.82±0.15, enhancing participants' understanding ($p<0.001$).

Table 5 reflects participants' knowledge regarding post-BMT care following an educational program. At baseline, 58.8% demonstrated poor knowledge, 23.5% exhibited fair and 17.6% had good knowledge. The mean knowledge score was 0.43±0.32, highlighting a limited understanding of post-transplant care. Post-program, there was a substantial decrease in those with poor knowledge (8.8%), those with fair knowledge increased to 29.4% and those having good knowledge rose significantly to 61.8%. Furthermore, the mean knowledge score improved to 0.79±0.13, indicating a marked enhancement in knowledge levels ($p<0.001$).

Table 6 demonstrates participants' knowledge regarding the care of central venous devices following an educational program. At baseline, 52.9% exhibited poor knowledge, 29.4% fair knowledge and 17.6% had good knowledge. The mean score was 0.39±0.38, reflecting a limited understanding of central venous device care. Post-program, those with poor knowledge decreased to 5.9%, those with fair knowledge decreased to 23.5% and those

Table 7: Distribution of participants' knowledge regarding discharge plan and patients' education

Level of knowledge	Baseline		Post-program		p-value
	Frequency	%	Frequency	%	
Knowledge regarding discharge plan					
Poor	22	64.7	3	8.8	>0.001*
Fair	8	23.5	11	32.4	
Good	4	11.8	20	58.8	
Mean±SD (0-1)	0.33±0.26		0.77±0.15		>0.001**
Knowledge regarding patient education					
Poor	20	58.8	3	8.8	>0.001*
Fair	9	26.5	10	29.4	
Good	5	14.7	21	61.8	
Mean±SD (0-1)	0.41±0.30		0.77±0.17		>0.001**

*Chi-square, **Paired t-test

Table 8: Distribution of overall participants' knowledge regarding bone marrow transplant

Level of knowledge	Baseline		Post-program		p-value
	Frequency	%	Frequency	%	
Poor	23	67.6	2	5.6	>0.001*
Fair	7	20.6	7	20.6	
Good	4	11.8	25	73.5	
Mean±SD (0-1)	0.42±0.23		0.79±0.12		>0.001**

*Chi-square, **Paired t-test

Table 9: Distribution of nurses' practice in preparation for bone marrow transplant

Level of Practice	Baseline		Post-program		p-value
	Frequency	%	Frequency	%	
Poor	22	64.7	5	14.7	>0.001*
Fair	9	26.6	10	29.4	
Good	3	8.8	19	55.9	
Mean±SD (0-2)	0.81±0.42		1.41±0.40		>0.001**

*Chi-square, **Paired t-test

Table 10: Distribution of nurses' practice during bone marrow transplant procedure

Level of Practice	Baseline		Post-program		p-value
	Frequency	%	Frequency	%	
Poor	21	61.8	4	11.8	>0.001*
Fair	10	29.4	12	35.3	
Good	3	8.8	18	52.9	
Mean±SD (0-2)	0.81±0.39		1.42±0.39		>0.001**

*Chi-square, **Paired t-test

with good knowledge increased significantly to 70.6%. The mean knowledge score improved notably to 0.81±0.14, indicating a substantial overall enhancement in knowledge levels ($p<0.001$).

Table 7 presents the distribution of participants' knowledge regarding the discharge plan and patient education. At baseline, 64.7% demonstrated poor knowledge of the discharge plan, with 23.5% fair knowledge and 11.8% good knowledge. Post-program, 8.8% had poor knowledge, 58.8% had good and 32.4% had fair. The mean score increased significantly from 0.33±0.26 to 0.77±0.15 post-program, indicating a marked improvement in participants' understanding of the discharge plan ($p<0.001$). As for knowledge regarding patient education, at baseline, 58.8% had poor knowledge, 26.5% had fair knowledge and 14.7% had good. Following the program, 8.8% had inadequate knowledge, 61.8% had good knowledge and 29.4% had fair knowledge. The mean score improved from 0.41±0.30 to 0.77±0.17, reflecting a substantial gain in knowledge about patient education ($p<0.001$).

Table 8 demonstrates participants' overall knowledge regarding BMT following an educational program. At baseline, 67.6% demonstrated poor knowledge, 20.6% exhibited fair and 11.8% had good. The mean knowledge score was 0.42±0.23, reflecting a limited understanding of BMT-related topics. Post-program, those with poor knowledge decreased to 5.6%, those with fair knowledge remained unchanged at 20.6%, while those with good knowledge increased substantially (73.5%). Additionally, the mean score improved significantly to 0.79±0.12, indicating a marked enhancement in knowledge levels ($p<0.001$).

Table 9 demonstrates nurses' practices regarding the preparation for BMT following an educational intervention. At baseline, 64.7% exhibited poor practice, 26.6% had fair and 8.8% demonstrated good. The mean score was 0.81±0.42 (out of 2), indicating relatively low levels of practice in BMT preparation. Post-program, the number of nurses with poor practice decreased significantly to 14.7%, those with fair practice slightly increased to 29.4%, while the number of nurses with good practice rose to 55.9%. Furthermore, the mean score improved to 1.41±0.40, reflecting a marked enhancement in practice levels ($p<0.001$).

Table 10 highlights a significant improvement in nurses' practice during the BMT procedure following an

Table 11: Distribution of nurses' practice in caring of central venous devices

Level of Practice	Baseline		Post-program		p-value
	Frequency	%	Frequency	%	
Poor	19	55.9	1	2.9	>0.001*
Fair	11	32.4	10	29.4	
Good	4	11.8	23	67.6	
Mean±SD (0-2)	0.85±0.38		1.57±0.27		>0.001**

*Chi-square, **Paired t-test

Table 12: Distribution of nurses' practice in post-transplant regarding assessment, monitoring and evaluation

Level of Practice	Baseline		Post-program		p-value
	Frequency	%	Frequency	%	
Assessment					
Poor	26	67.6	4	11.8	>0.001*
Fair	9	26.5	14	41.2	
Good	2	5.9	16	47.1	
Mean±SD (0-2)	0.56±0.50		1.37±0.35		>0.001**
Monitoring					
Poor	26	64.7	5	14.7	>0.001*
Fair	10	29.4	13	38.2	
Good	2	5.9	16	47.1	
Mean±SD (0-2)	0.57±0.48		1.44±0.30		>0.001**
Evaluating					
Poor	22	64.7	4	11.8	>0.001*
Fair	9	26.5	13	38.2	
Good	3	8.8	17	50	
Mean±SD (0-2)	0.41±0.58		1.30±0.43		>0.001**

*Chi-square, **Paired t-test

educational program. At baseline, 61.8% demonstrated poor practice, 29.4% exhibited fair and 8.8% displayed good. The mean score was 0.81±0.39, indicating relatively low competency levels in BMT procedures. Post-program, the nurses with poor practice decreased markedly to 11.8%, those with fair practice increased to 35.3% and those demonstrating good practice rose significantly to 52.9%. Additionally, the mean practice score improved to 1.42±0.39, reflecting a marked enhancement in the level of practice ($p<0.001$).

Table 11 reveals a significant improvement in nurses' practices regarding the care of central venous devices following an educational intervention. At baseline, 55.9% demonstrated poor practice, 32.4% exhibited fair and 11.8% demonstrated good. The mean score was 0.85±0.38, indicating a need for substantial improvement in central venous device care practices. Post-program, the number of nurses with poor practice decreased to 2.9%, those with fair remained stable at 29.4% and those demonstrating good practice rose significantly to 67.6%. The mean score increased to 1.57±0.27, reflecting a marked enhancement in practice levels ($p<0.001$).

Table 12 demonstrates the nurses' practice in assessing, monitoring and evaluating BMT patients. At baseline, 67.6% demonstrated poor practice, 26.5% fair practice and 5.9% had good practice. The mean score was 0.56±0.50. Post-program, the nurses with poor practice decreased significantly to 11.8%, fair practice increased to 41.2% and those with good practice rose markedly to 47.1%. The mean score improved to 1.37±0.35. Similarly, in monitoring practices, at baseline, 64.7% showed poor practice, 29.4% fair practice and 5.9% displayed good practice, with a mean score of 0.57±0.48. Post-program, poor practice decreased to 14.7%, fair increased to 38.2% and good rose to 47.1%. The mean score significantly improved to 1.44±0.30. Regarding evaluation, 64.7% exhibited poor, 26.5% fair practice and 8.8% demonstrated good practice, with a mean score of 0.41±0.58. Post-program, the poor practice decreased to 11.8%, fair practice increased to 38.2% and good practice improved to 50%. The mean score increased significantly to 1.30±0.43. The improvements observed across assessment, monitoring and evaluation practices are highly significant ($p<0.001$).

Table 13 highlights nurses' practices regarding infection control following the program. At baseline, 61.8% demonstrated poor practices, 29.4% exhibited fair and 8.8% showed good. The mean score was 0.56±0.47. Post-program revealed a reduction in poor practice to 11.8%, while fair practice increased to 32.4%. Good infection control practices rose to 55.9%. The mean practice score significantly improved to 1.42±0.35 ($p<0.001$).

Table 14 demonstrates nurses' practices related to pain management after the intervention. At baseline, 73.5% exhibited poor practices, 20.6% had fair and 5.9% had good. The mean score before the program was 0.53±0.42, indicating low competency in this area. Following the program, the number of nurses with poor practices significantly decreased to 11.8%. Meanwhile, those with fair practices increased to 38.2% and those demonstrating good practices rose to 50%. The mean score improved significantly to 1.30±0.25 ($p<0.001$).

Table 15 indicates nurses' nutrition and hydration management practices at baseline and after the educational intervention. At baseline, 67.6% demonstrated poor practices in managing nutrition, while 26.5% had fair and 5.9% exhibited good. The mean score for nutrition was

Table 13: Distribution of nurses' practice regarding infection control

Level of Practice	Baseline		Post-program		p-value
	Frequency	%	Frequency	%	
Poor	21	61.8	4	11.8	>0.001*
Fair	10	29.4	11	32.4	
Good	3	8.8	19	55.9	
Mean±SD (0-2)	0.56±0.47		1.42±0.35		>0.001**

*Chi-square, **Paired t-test

Table 14: Distribution of nurses' practice in pain management

Level of Practice	Baseline		Post-program		p-value
	Frequency	%	Frequency	%	
Poor	25	73.5	4	11.8	>0.001*
Fair	7	20.6	13	38.2	
Good	2	5.9	17	50	
Mean±SD (0-2)	0.53±0.42		1.30±0.25		>0.001**

*Chi-square, **Paired t-test

Table 15: Distribution of nurses' practice regarding nutrition and hydration

Level of Practice	Baseline		Post-program		p-value
	Frequency	%	Frequency	%	
Nutrition					
Poor	23	67.6	5	14.7	>0.001*
Fair	9	26.5	11	32.4	
Good	2	5.9	18	52.9	
Mean±SD (0-2)	0.46±0.49		1.35±0.39		>0.001**
Hydration					
Poor	19	55.9	3	8.8	>0.001*
Fair	12	35.3	9	26.5	
Good	3	8.8	22	64.7	
Mean±SD (0-2)	0.75±0.27		1.26±0.26		>0.001**

*Chi-square, **Paired t-test

Table 16: Distribution of nurses' practice regarding oral care and mucositis management

Level of Practice	Baseline		Post-program		p-value
	Frequency	%	Frequency	%	
Oral Care					
Poor	22	64.7	3	8.8	>0.001*
Fair	9	26.5	12	35.3	
Good	3	8.8	19	55.9	
Mean±SD (0-2)	0.50±0.56		1.38±0.40		>0.001**
Mucositis Management					
Poor	24	70.6	4	11.8	>0.001*
Fair	7	20.6	13	38.2	
Good	3	8.8	17	50	
Mean±SD (0-2)	0.63±0.47		1.45±0.37		>0.001**

*Chi-square, **Paired t-test

0.46±0.49, reflecting a low proficiency. Post-program showed a reduction in poor practices to 14.7%, with an increase in fair practices to 32.4% and good practices to 52.9%. The mean score significantly increased to 1.35±0.39. In hydration management, baseline results indicated that 55.9% had poor practices, 35.3% had fair practices and 8.8% had good practices. The mean score was 0.75±0.27. Following the program, the proportion of nurses with poor practices decreased to 8.8%, while those with fair practices slightly declined to 26.5%. Significantly, the number of nurses with good practices increased dramatically to 64.7%. The mean practice score for hydration management also considerably improved to 1.26±0.26 ($p<0.001$).

Table 16 demonstrates nurses' practices related to oral care and mucositis management at baseline and following the educational intervention. At baseline, 64.7% exhibited poor practices, 26.5% had fair and 8.8% had good. The mean score was 0.50±0.56, indicating limited proficiency in this area. After the program, nurses with poor practices decreased to 8.8%, while those with fair practices increased to 35.3%. The nurses with good practices saw a substantial rise to 55.9%. The mean practice score significantly improved to 1.38±0.40. For mucositis management, baseline data showed that 70.6% had poor practices, 20.6% demonstrated fair and 8.8% exhibited good practices. The mean score was 0.63±0.47, reflecting a need for improvement. Post-program indicated a significant reduction in poor practices to 11.8%, while fair practices increased to 38.2%. The number of nurses with good practices rose to 50%. The mean practice score increased significantly to 1.45±0.31 ($p<0.001$).

Table 17 highlights significant nurses' practices concerning providing emotional support to patients after the intervention. At baseline, 58.8% demonstrated poor practices, 32.4% had fair and 8.8% had good practices. The

Table 17: Distribution of nurses' practice regarding emotional support

	Baseline		Post-program		
Level of Practice	Frequency	%	Frequency	%	p-value
Poor	20	58.8	6	17.6	>0.001*
Fair	11	32.4	11	32.4	
Good	3	8.8	17	50	
Mean±SD (0-2)	0.65±0.50		1.40±0.40		>0.001**

*Chi-square, **Paired t-test

Table 18: Distribution of nurses' practice regarding discharge plan

	Baseline		Post-program		
Level of Practice	Frequency	%	Frequency	%	p-value
Poor	21	61.8	3	8.8	>0.001*
Fair	11	32.4	10	29.4	
Good	2	5.9	21	61.8	
Mean±SD (0-2)	0.61±0.52		1.42±0.33		>0.001**

*Chi-square, **Paired t-test

Table 19: Distribution of nurses' practice regarding patient's education

	Baseline		Post-program/34		
Level of Practice	Frequency	%	Frequency	%	p-value
Poor	20	58.8	3	8.8	>0.001*
Fair	10	29.4	9	26.5	
Good	4	11.8	22	64.7	
Mean±SD (0-2)	0.63±0.58		1.45±0.38		>0.001**

*Chi-square, **Paired t-test

Table 20: Distribution of overall nurses' practice

	Baseline		Post-program		
Level of Practice	Frequency	%	Frequency	%	p-value
Poor	25	73.5	4	11.8	>0.001*
Fair	7	20.6	16	47.1	
Good	2	5.9	14	41.2	
Mean±SD (0-2)	0.63±0.42		1.40±0.29		>0.001**

*Chi-square, **Paired t-test

mean score was 0.65±0.50, reflecting inadequate skills. Post-program, poor practices declined significantly to 17.6%, indicating a marked improvement. Those with fair practices remained stable at 32.4%, while good practices increased to 50%. The mean practice score significantly improved to 1.40±0.40 ($p<0.001$).

Table 18 shows nurses' discharge planning practices at baseline and after the educational program. At baseline, 61.8% of nurses displayed poor practices, 32.4% fair and 5.9% good with a mean score of 0.61±0.52, indicating inadequate proficiency. Post-program, poor practices decreased to 8.8%, fair remained relatively stable at 29.4% and good practices surged to 61.8%. The mean score significantly improved, increasing to 1.42±0.33 ($p<0.001$).

Table 19 highlights nurses' practices in providing patient education at baseline and after the intervention. At baseline, 58.8% exhibited poor practices, while 29.4% had fair and 11.8% displayed good with the mean score of 0.63±0.58, reflecting suboptimal proficiency. After the program, poor practices declined to 8.8%, the fair was 26.5% and good increased to 64.7%. The mean score improved highly significantly to 1.45±0.38 ($p<0.001$).

Table 20 indicates nurses' overall practice at baseline and after the intervention. At baseline, 73.5% had poor practices, 20.6% fair and 5.9% good. The mean score was 0.63±0.42, which reflects a suboptimal practice among the nurses. Post-program, there was a substantial shift in practice levels, as poor practices decreased to 11.8%, 47.1% had fair and 41.2% had good practices. The mean score highly significantly improved to 1.40±0.29 ($p<0.001$).

DISCUSSION

The primary objective of this study was to assess the impact of an educational intervention on nurses' knowledge and practices related to BMT. The predominance of younger nurses, with >2/3 of the sample falling within the 30-40 age group and a mean age of 32.76 years, indicates that the workforce is relatively young. This may suggest a dynamic and potentially adaptable workforce, although it highlights the need for ongoing professional development to harness their potential effectively. Regarding gender, >2/3 were females, indicating a noticeable gender imbalance in the nursing workforce. This trend is consistent with global patterns in healthcare, where nursing remains a predominantly female profession.

Educational qualifications among the participants also reveal a significant reliance on diploma-level education, which is common in many healthcare settings. However, the relatively low number of nurses with bachelor's (1/4) or postgraduate degrees (<1/10) may reflect the challenges in advancing educational qualifications in healthcare environments, possibly due to time constraints or financial barriers. The relatively moderate level of experience, with a mean nursing experience of 10.21 years, suggests that while

the workforce is experienced, there may be room for growth in expertise, particularly in specialized fields such as BMT.

Regarding specific experience in the BMT unit, >6 out of 10 nurses had <5 years of experience, which aligns with the overall trend of younger, less experienced staff. This indicates a need for targeted training programs to enhance their competency in BMT. Almost 2/3 of nurses had not attended formal training courses related to BMT, underscoring the critical professional development gap within this specialized area. This lack of specialized training may impact the quality of care provided to patients undergoing BMT procedures, highlighting the importance of structured educational programs to improve knowledge and practice. Thus, training and education in BMT for nurses, particularly those with less experience, is essential to improve patient outcomes and advance the quality of care in the unit. Ali *et al.* [7] showed that most nurses aged 18-25 with bachelor's degrees lacked prior training in BMT. These findings underscore the necessity for ongoing educational interventions to equip nurses with the skills needed to provide high standards of care, aligning with the conclusions of previous studies on the effectiveness of teaching programs in improving nursing knowledge and practice.

This study also highlights a significant improvement in the participants' knowledge regarding various aspects of BMT following an educational intervention. Before the program, participants demonstrated limited knowledge across multiple domains, with a substantial proportion exhibiting poor knowledge. However, post-program assessments revealed a dramatic shift towards improved knowledge, with most participants demonstrating good knowledge about BMT, its indications and contraindications, complications, nurse responsibilities, preparation for the procedure, post-transplant care and patient education.

In general, BMT participants with poor knowledge decreased from 1/2 at baseline to <6% post-program. The significant improvement in knowledge is indicated by the mean score increasing from 0.41±0.29 to 0.82±0.13 ($p<0.001$). Similarly, in knowledge regarding the indications and contraindications of BMT, the participants with sound knowledge rose significantly from 1/5 to >2/3, with the mean score improving from 0.44±0.28 to 0.79±0.15 ($p<0.001$), suggesting the educational program successfully addressed knowledge gaps in critical areas, which are essential for ensuring safe and effective care for BMT patients.

The results also showed a marked improvement in nurse's responsibilities before BMT and the preparation required for the procedure. At baseline, >1/2 exhibited poor knowledge but following the program, the mean scores increased from 0.44±0.28 to 0.78±0.13 for nurse responsibilities and from 0.48±0.27 to 0.78±0.14 for BMT preparation ($p<0.001$), indicating the intervention's success in improving clinical preparedness.

Post-transplant care and central venous device care were also areas where significant improvements were observed. Participants' knowledge of these critical aspects increased dramatically, with those demonstrating good knowledge increasing from <1/5 to almost 2/3 in post-transplant care and from <2-7 out of 10 nurses in central venous device care ($p<0.001$), suggesting that the educational program effectively equipped nurses with the necessary knowledge for post-transplant care and the management of BMT-related complications.

Furthermore, substantial gains in knowledge regarding discharge planning and patient education were seen. Following the intervention, the majority showed good knowledge, with mean scores improving from 0.33±0.26 to 0.77±0.15 for discharge planning and from 0.41±0.30 to 0.77±0.17 for patient education ($p<0.001$). This is important as discharge planning and patient education are key components in ensuring patient safety and effective recovery after BMT. The data support that the educational intervention significantly enhanced the participants' knowledge in BMT-related areas. This improvement could have meaningful implications for the quality of care nurses provide in BMT Units, leading to better patient outcomes. These findings align with the effectiveness of targeted educational programs in improving healthcare providers' knowledge and skills. The results underline the importance of continuous professional development and specialized training in advancing nursing practice, particularly in BMT. The improvements suggest that regular educational interventions are vital for enhancing nurses' competence and ensuring high standards of patient care.

The previous study demonstrated that an educational program significantly improved nurses' knowledge and practices concerning BMT management, with highly significant differences observed before and after the program ($p<0.001$). Elsantawy *et al.* [5] underscore the importance of equipping nurses with a thorough understanding of potential complications associated with BMT, such as sepsis, fluid overload and organ malfunction. This knowledge enables nurses to recognize warning signs early and take appropriate actions to mitigate negative outcomes and restore patients' clinical status. Additionally, they emphasize the critical role of nurses in providing comprehensive education to patients and their families before discharge. This education covers essential aspects such as post-transplant restrictions, dietary guidelines, medication management, fluid balance, interpreting test results and the importance of follow-up care. These reinforce the need for specialized nurse training and education to ensure effective patient management and improve outcomes following BMT.

Mohamed *et al.* [8] revealed a significant gap before implementing the educational intervention, as most nurses demonstrated poor knowledge, highlighting a pressing need for targeted educational initiatives. Following the intervention, a dramatic improvement in knowledge was observed, as most nurses achieved a comprehensive understanding of SCT, underscoring the program's effectiveness. Adel *et al.* [6] showed that most nurses had better knowledge of following post-educational guidelines than pre-educational guidelines.

On the other hand, Ali *et al.* [7] demonstrated a significant improvement in the overall knowledge levels of nurses regarding BMT following the educational program. Before the intervention, nurses exhibited low levels of knowledge; after the program, a highly significant improvement ($p<0.001$) was seen. This underscores the critical role of targeted interventions in equipping nurses with the knowledge to manage complex medical procedures effectively. Khalil *et al.* [9] revealed a significant improvement in nurses' knowledge and practices regarding BMT following the evidence-based guidelines. In pre-implementation, <1/5 of nurses demonstrated good understanding, which increased to 3/4 post-implementation.

Abd El-Fattah *et al.* [10] found that >4/5 of nurses had satisfactory knowledge levels about SCT. In practice, these nurses demonstrated competent levels of SCT-related practices with a strong positive correlation between nurses' knowledge and practice across various dimensions of SCT care, including chemotherapy and SC phases. Kim & Shin, 2019 highlight the effectiveness of educational programs in improving nursing students' knowledge, attitudes and intentions toward HSC donation. Pretest results showed no significant differences in knowledge or attitudes between experimental and control groups. However, the post-test revealed significant improvements in the experimental group's knowledge and attitudes [11]. Their findings indicate a significant impact of an intervention on nurses' practices related to BMT care. Also, they stated that before the intervention, most nurses exhibited poor to fair, with only a few having good practices. However, following the program, marked improvement in practice level was observed across all domains, with significant shifts towards better practices in BMT preparation, infection control, pain management, patient education and emotional support. This improvement is consistent with the educational program's goals designed to enhance nurses' knowledge/skills related to BMT care [11].

At baseline, most of our studied nurses (>1/2) across the various areas demonstrated poor practices, as evidenced by mean practice scores (>1/2). The educational program led to a significant reduction in poor practices and increased nurses with good practices. For example, in BMT preparation, the nurses with poor practice decreased from 2/3 to 15, with a corresponding increase in good practices from <1/10 to >1/5 and a substantial rise in the mean score from 0.81±0.42 to 1.41±0.40. Similar improvements were observed in the other practice areas, such as infection control, pain management, nutrition and hydration management, where poor practices decreased dramatically and the nurses with good practices rose significantly.

The improvement in nurses' practices can be attributed to the educational program's comprehensive approach, which likely provided targeted knowledge, practical skills and the necessary tools to enhance nurses' competence in managing complex aspects of BMT care. These results align with Khalil *et al.* [9], who demonstrated the effectiveness of education-based interventions in improving healthcare practices [9]. They show that educational programs can significantly improve clinical practices, particularly in specialized fields like oncology and transplant care, with a significant improvement in nurses' knowledge and practices regarding BMT following the evidence-based guidelines. They observed that 1/3 of nurses had satisfactory practices in BMT care pre-implementation, which improved to a majority post-intervention. Also, Ali *et al.* [7], Mohamed *et al.* [8], Abd El-Fatah [10] and Adel *et al.* [6] similarly reported significant improvements in nurses' knowledge and practices post-training intervention and following tailored educational interventions focused on specific aspects of patient care.

Furthermore, improvements in emotional support and discharge planning highlight the broad impact of the interventions that are often underemphasized in clinical education, which are critical in improving patient outcomes and enhancing the quality of care. The increase in nurses' good practices in emotional support from <10 to 1/2 and discharge planning from <6 to >60% suggests that the intervention successfully fostered a more holistic approach to patient care. These outcomes parallel those of Mohamed *et al.* [8], who demonstrated significant improvements in nurses' performance in managing patients undergoing BMT after the program, emphasizing the effectiveness of targeted training. Neumann [12] also highlighted the crucial role of nurses in assessing, monitoring and supporting patients undergoing SCT, emphasizing the importance of training in managing infections, transfusion reactions and central venous catheter issues. Additionally, Faulkner *et al.* [13] reinforced the need for nurse education in BMT preparation, specifically in conducting pre-transplant evaluations, addressing patient and family concerns and managing donor care.

The critical role of nurses in guiding patients and families through complex care options is essential, particularly in emotionally charged contexts where illness, loss and anticipatory grief can complicate the learning process. As Khalil *et al.* [9] emphasised, hospitals must ensure that nursing staff possess the necessary knowledge, experience and training to manage these challenges effectively. A training plan is necessary to maintain staff competence, ensuring nurses can perform tasks aligned with their roles and responsibilities. This highlights the importance of ongoing education and training in supporting nurses to provide comprehensive and compassionate care in demanding clinical settings. The significant improvements observed in infection control practices, as poor infection control practices reduced from 2/3 to 1/10 and increase in good practices from 1 to 6, underscore the importance of ongoing education in preventing infection and improving patient safety. This is consistent with that of Khalil *et al.* [9], who demonstrated that interventions in infection control significantly reduced hospital-acquired infections and improved clinical outcomes.

The improvements in practice scores across multiple domains reflect a comprehensive enhancement in nursing care that can contribute to better patient outcomes in BMT settings. The intervention is particularly effective in fostering knowledge retention and skill application, leading to sustainable changes in practice. This finding is consistent with Ferreira *et al.* [14] highlighted the impact of targeted interventions on improving nursing practices and emphasized that comprehensive training in infection prevention, oral care and catheter management is essential for enhancing patient outcomes in BMT settings. Similarly, Oliveira [15] found that education programs tailored to the unique demands of transplantation care significantly bolster nurses' ability to manage complex clinical scenarios effectively.

Among the various domains, the most significant improvement was observed in the practices related to infection control and central venous device care, where nurses showed the most dramatic shifts from poor to good practices. This likely reflects the critical nature of these areas in preventing complications and improving patient outcomes, making them prime targets for education. The mean practice scores for infection control (1.42±0.35) and central venous device care (1.57±0.27) were the highest post-program. In contrast, significant improvements in pain management and nutrition demonstrate a slightly less pronounced shift toward good practice levels. This could be attributed to these domains' complex and multifaceted nature, which may require continuous reinforcement to maintain high standards.

The educational intervention had a robust impact, as evidenced by significant differences in mean practice scores and categorical practice levels across all areas. This underscores the effectiveness of the intervention in transforming nursing practices. However, a gap remains in fair practices, where some nurses exhibit neither poor nor ideal practices. This indicates the potential need for more targeted interventions or follow-up training to bridge this gap, particularly in patient education and discharge planning.

CONCLUSIONS

The outcomes support the effectiveness of educational interventions in improving nurses' practices related to BMT care. The significant improvements across a wide range of clinical areas indicate that targeted education can significantly enhance nurses' competency, leading to improved patient care. These findings have important implications for nursing education and practice, suggesting that similar educational interventions can be implemented in other specialized clinical settings to improve care outcomes.

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